

EC-2

96kHz Sample Rate Upgrade A/D and D/A Converter Cards

for the ADAT HD24 Hard Disk Recorder

OWNER'S MANUAL

VERSION 1.0

APPLIES TO ADAT HD24 SOFTWARE VERSION 1.05 AND ABOVE

ALESIS

AUDIO RENTS, INC.

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EC-2 96kHz Upgrade Cards

This document covers only those aspects unique to the EC-2 cards and should be kept with the HD24 manual.

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Important Safety Instructions

Safety symbols used in this product



This symbol alerts the user that there are important operating and maintenance instructions in the literature accompanying this unit.



This symbol warns the user of uninsulated voltage within the unit that can cause dangerous electric shocks.

All safety warnings in the HD24 manual (pages 7 through 10) apply to the EC-2 as well.

CE Declaration of Conformity

For the CE Declaration of Conformity, please visit the Alesis web site at: www.alesis.com

About the EC-2

The EC-2 is an optional 96kHz sampling rate analog hardware upgrade designed exclusively for the Alesis ADAT HD24. It provides 24 simultaneous channels of balanced +4 dBu analog audio inputs and outputs via 48 1/4" TRS type jacks. The EC-2 is installed directly inside the HD24's rear panel, in place of the original A/D and D/A boards, for simple system integration and flexibility. With the EC-2 installed, the HD24 can record and play back digital audio at the 96kHz or 88.2 kHz sampling rates (in addition to the standard 44.1 and 48 kHz rates) via its analog inputs and outputs. In high sample rate mode, the HD24 can record and play back up to 12 tracks at a time.

The EC-2 expansion cards are designed for use only with HD24 software version 1.05 or higher. If your HD24 has a lower software version, visit our web site at www.alesis.com to download the latest HD24 software and instructions for updating the HD24 via a standard MIDI file or via Ethernet. If you don't have a computer or MIDI sequencer, contact your Alesis dealer or local service center to help you with the upgrade.

The EC-2 upgrade boards are a replacement for the standard HD24 analog converter boards. They do everything the standard boards do, plus:

- **24 channels of High Performance 24-bit Analog Audio Conversion.** 24 channels of simultaneous input and output on 1/4" TRS jacks. Superior DACs and ADCs allow the EC-2 to considerably surpass the standard converter boards in THD+N and dynamic range.
- **Support for Sample Rates up to 96kHz.** The EC-2 boards allow you to use analog inputs and outputs at 88.2kHz and 96kHz nominal sample rates.
- **Simple hookup and operation.** The EC-2 is designed to install in the rear panel of the HD24 and connects to the main circuit board with the included multi-pin ribbon connectors. Once connected, the HD24 will detect the cards' presence, and allow you to select analog inputs as the source when using the 88.2kHz and 96kHz sample rates.

Installing the EC-2 into the HD24

Precautions



The EC-2 boards should only be installed by a dealer or trained technician. End users should only attempt installation if they have experience with this type of procedure. If any of the following instructions are not clear to you, please have a dealer or trained technician install it for you. Improper installation by the end user may damage the boards and/or your HD24 and may void your warranty.

Packing List

In the EC-2 box, you should find the following items:

- This manual (P/N 7-51-0107, E2 User's Manual)
- 96 kHz Analog Input board (P/N 9-40-0256, E2 A/D PCB)
- 96 kHz Analog Output board (P/N 9-40-0257, E2 D/A PCB)
- Daughterboard (P/N 9-40-0258, E2 D/D PCB)
- DC power cable (P/N 4-74-0031, E2 DC Power Cable)

Before you begin, verify that you have everything in this packing list. When you unwrap the components, save the packing materials so you can use them to store the original parts.

Overview

In the HD24, the conversion between analog and digital signals takes place on two PCBs (printed circuit boards) that are mounted directly to the input (A/D) and output (D/A) connectors that poke through the back panel. In a "stock" HD24 without 96 kHz sampling capability, each card connects directly to the main PCB on the bottom of the unit with a ribbon cable.

To add 96kHz analog recording and playback capability, both the input and output boards are completely replaced, and another board (the daughterboard) is added bridging across them. The daughterboard then connects via ribbon cables to the main PCB. The daughterboard requires a connection to the power supply, so the existing 4-conductor power cable must be replaced with a new 5-conductor power cable.

Tools required

Before you begin, have these tools ready:

- #2 Philips-head screwdriver
- 14 mm nut driver or socket wrench

Prepare to install:

1. Disconnect the HD24's AC power cable, and make sure you are working on a clean, flat, hard surface. Ground yourself by touching a grounded metal object. **An anti-static workstation with anti-static mat and wrist strap is highly recommended.**



Hazardous voltages are present within the chassis. Do not remove the top panel without first unplugging the unit from AC power!

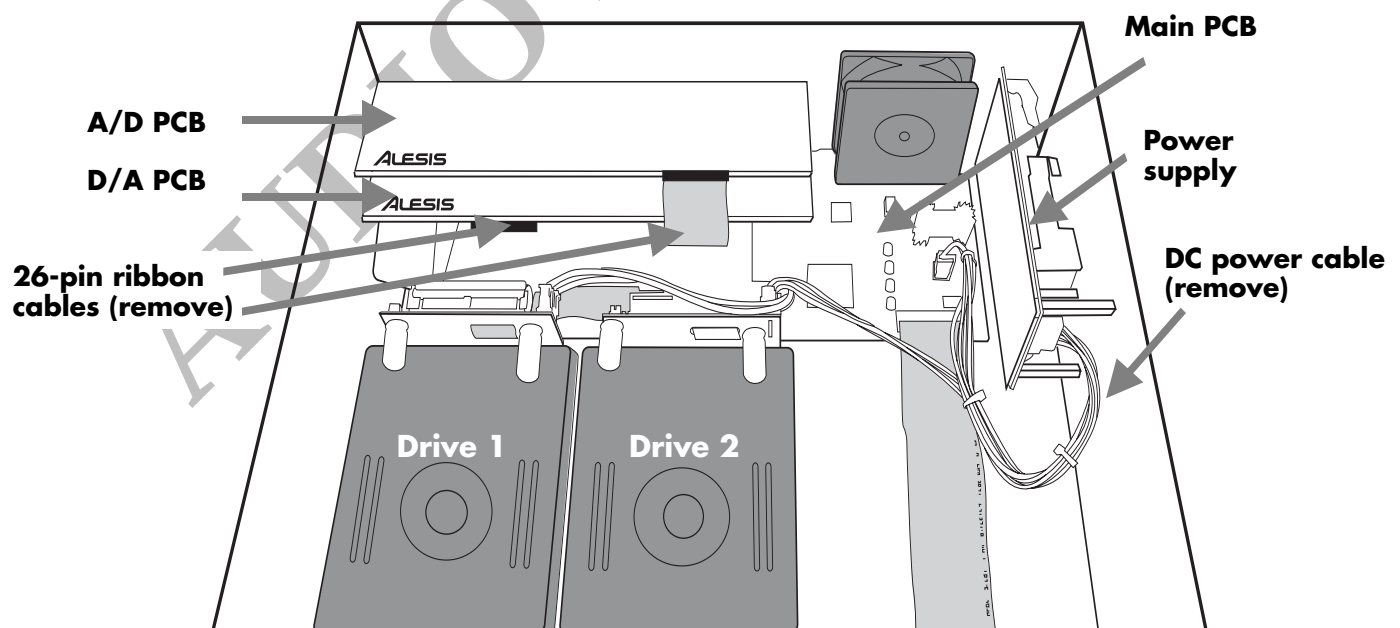
2. **Remove the cover from the HD24:** The cover is held to the body with 5 Philips head screws on the rear, 2 on each side, and one on the top. Slide the cover directly towards the rear; don't lift it up—there are metal tabs on the back panel and along the bottom that will get bent if you do.

Remove the existing converter PCBs and cables:

3. **Locate the existing DC power cable.** This cable has several thick red, orange, yellow, black, and blue wires bundled together. Pinch the tab lock holding the white connector to the back of Drive 1 and carefully disconnect it. Do the same for the connector on Drive 2, the Main PCB (the printed circuit board on the floor of the HD24), and finally the power supply itself. *(This will be replaced with a new cable in step 14.)*
4. Disconnect the 26-pin flexible ribbon cables from the existing converter PCBs and the main PCB, and remove them completely.

New 26-pin cables are attached to the EC-2 daughterboard—the old ones will not be used.

5. Remove the 24 nuts and washers on the 1/4" input connectors, holding the PCB in place to keep it from falling. Then remove the old A/D PCB (the highest one on the back panel).
6. Do the same for the 24 nuts and washers on the 1/4" output connectors. Hold the PCB in place to prevent the D/A PCB from dropping onto the main PCB. *Once the PCBs are removed, put the nuts and washers back on the jacks and store these PCBs and cables in the packaging that the EC-2 came in.*

HD24 interior with original A/D/A PCBs

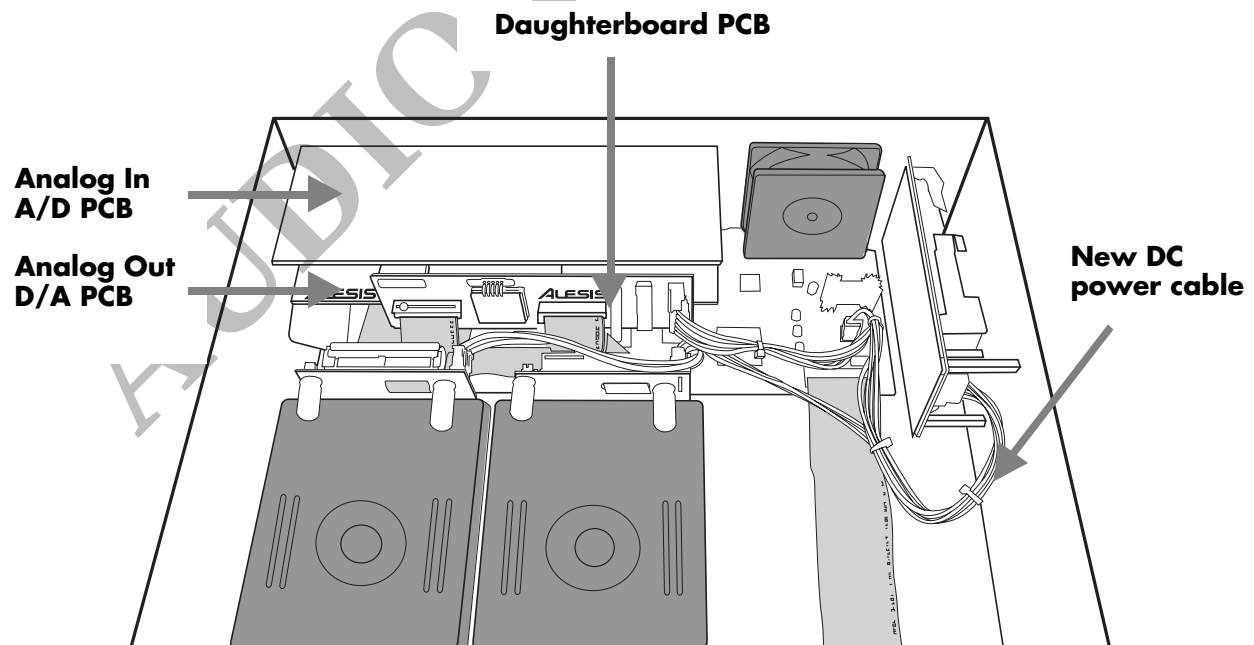
Install the new EC-2 PCBs

7. Find the daughterboard in the EC-2 package: it has two 26-pin flexible cables attached to it. Insert the ribbon connector labeled “J4 TO MAIN PCB” on the daughterboard into the 26-pin header labeled on the main PCB as “J15 TO A/D PCB”.
 8. Insert the ribbon connector labeled “J3 TO MAIN PCB” on the daughterboard into the 26-pin header labeled on the main PCB as “J14 TO D/A PCB”.
- The headers on the main PCB sit near the back center, where the old input/output PCBs used to plug in. The red side of each cable should face the right of the HD24 (closest to the fan). Verify that the cables don't have any twists in them and that there are no unconnected or exposed pins on the headers.*
9. Lay the daughterboard gently on the PCBs at the rear of the hard drive cages until the Analog Input and Analog Output PCBs are installed.
 10. Get the new Analog Output (D/A) PCB from its packaging. Remove the nuts and washers from the 1/4" connectors on the new Analog Output (D/A) PCB.

NOTE: The Analog Input and Analog Output PCBs look very similar. Verify that you have the correct PCB by looking for the part number and part name in the text in the corner of the PCB.

11. Place the Analog Output PCB in the bottom set of rear panel holes (labeled OUTPUT on the rear panel) with the components facing down (so that you can read the white text on the PCB, which says “D/A PCB” and “Analog Output”). Put a few of the washers and nuts on the 1/4" jacks to hold the PCB in place. Screw them down all the way, but do not tighten yet—it should be just a little loose.
12. Place the Analog Input PCB in the top set of rear panel holes (labeled INPUT on the rear panel) with the components facing down and put a few of the washers and nuts on the 1/4" jacks to hold the PCB in place. Screw them down all the way, but do not tighten.

HD24 with EC-2 installed



Connect the PCBs

13. **Connect the daughterboard to the Input and Output PCBs:** Line up the connectors to the bottom (D/A) and top (A/D) PCBs, make sure all the pins line up, then gently push the daughterboard to the rear of the HD24 using the plastic ribbon cable headers as pressure points, making a connection between all three PCBs.

The connectors will only line up in one orientation. Verify that there are no pins unconnected or exposed.

14. Put the remainder of the washers and nuts on the jacks of the input and output connectors and tighten them all down (total 48 jacks).
15. Install the new DC power cable, connecting the power supply, main PCB, daughterboard, and hard drive PCBs as shown in the illustration on the previous page. Run it from the daughterboard to the main PCB to the power supply, then back from the power supply to the two drives. Make sure the connectors snap into place securely.
16. Replace the top panel.

To test for proper installation

After installation, you will be able to select ANALOG input as well as DIGITAL with SAMPLE RATE set to 88.1 and 96kHz.

1. Plug the unit back in to AC power and turn on the HD24.
2. Select or create an 88.2kHz or 96kHz song.
3. Press **INPUT SELECT** until the "INPUT" group in the alphanumeric display indicates "ANALOG". This confirms that the HD24 has detected the EC-2's presence.

If it's not detected, unplug the unit and check all connections carefully, disconnecting and connecting each, then trying again to see if the EC-2 is detected. Contact Alesis Product Support or an authorized service center if the cards are still not detected.

Using the EC-2

For important information about high-resolution operation of the HD24, see Chapter 7 of your ADAT HD24 owner's manual (page 65).

About 96kHz/88.2kHz Sampling Operation

An ADAT HD24 with EC-2 upgrade boards installed operates identically to a "stock" HD24 with respect to input arming, selection, and routing (or "normalling"). The only difference is that you will be able to use **analog** inputs and outputs when the system is set to 88.2kHz or 96kHz sampling rates. (Without the EC-2, you must use the ADAT Optical digital inputs and outputs with an external 88.2/96kHz converter to record at higher sample rates.)

• About 12-channel operation at high sample rates

When recording and playing back any Song that has been initialized at the 88.2 or 96 kHz sampling rates, the HD24 is limited to recording a maximum of 12 channels.

- Analog input channels 13-24 will be ignored.
- Analog output channels 13-24 will duplicate output channels 1-12.
- Digital inputs and outputs are grouped in fours instead of eights: tracks 1-4 on the HD24's **ADAT OPTICAL 1-8** ports, tracks 5-8 on the HD24's **ADAT OPTICAL 9-16** ports, and tracks 9-12 on the HD24's **ADAT OPTICAL 17-24** ports. For more on operation of the ADAT Optical port, see page 66 of the HD24 manual.

When using an HD24/EC-2 at the standard 44.1kHz or 48kHz sampling rates, you will still be able to record and play back all 24 tracks. The only difference from the original boards will be improved audio performance, due to the higher quality converters and analog circuitry of the EC-2.

Synchronizing at high sample rates:

To record more than 12 tracks in the high sample rate mode, simply synchronize two HD24/EC-2 units together by linking them with an ADAT Sync cable (see page 24 of the HD24 manual). Up to five HD24s may be synchronized this way, allowing high-sample rate systems of up to 60 tracks.

Synchronizing two HD24s at different sample rates:

When synchronizing multiple HD24s (or an HD24 with tape-based ADATs) together, it is possible to have an HD24 record and play back a high sample rate Song, while other machines play back a standard sample rate Song.

In this case, the sample rates must be even multiples of each other (44.1 with 88.2 or 48 with 96 kHz).

For example, one HD24 can be running with 24 tracks of instrumental tracks at 48 kHz while a second HD24 records and plays back 12 tracks of vocals and leads at 96 kHz, for a total of 36 tracks simultaneously.

Depending on the software version of your HD24, a warning message may appear or the sample rate indicator may flash indicating the mismatch in rates, but this will not affect operation.

Inputs and Outputs

The inputs and outputs of the HD24/EC-2 are the same basic type as on a “stock” HD24: balanced 1/4” TRS jacks with a nominal +4 dBu level corresponding to –15 dBFS on the HD24’s meter. In most installations, there will be no difference in meter readings or levels after you install the EC-2.

However, there is a slight difference in the balancing circuitry that may affect some installations. The EC-2 features true differential inputs and outputs, with dual drivers on each output instead of the more common (and less expensive) “impedance balanced” (sometimes called “ground compensated”) method of balancing the outputs found on most audio gear (and on the original HD24 boards).

As a result, if you plug the output of the EC-2 into an unbalanced input, the nominal output will be –2 dBu, 6 dB less than if the EC-2 was seeing a true balanced load. This is normal operation and has no effect on the final quality of the sound...it only reduces the readings on the console’s tape return meters. To avoid this 6 dB loss, simply plug the outputs of the HD24/EC-2 into balanced inputs on the console.

About the EC-2's audio performance

An HD24 with the EC-2 upgrade has audio performance far superior to that of any analog recorder, and a wider dynamic range than most input and output devices that may be connected to it. Here's why:

The converter defines the sound

The first and last steps in digital recording—the conversion from analog to digital, then back again—define the audio quality of the digital recording process. Once captured in the digital domain as a series of ones and zeroes, the audio is protected for as long as the media lasts. So the converter you use when recording a master is one of the most important choices you can make in the studio.

The EC-2 upgrade uses premium AKM 5393 analog-to-digital (A/D) and AKM 4393 digital-to-analog (D/A) converters, among the best available today. The input and output electronics are virtually identical to those of the acclaimed Alesis MasterLink High-Resolution Master Disk Recorder. Even at standard sample rates, the noise floor and distortion are lower than most units costing much more. The noise floor is 10 dB lower than a “stock” HD24, and 20 dB lower than standard Compact Discs and the original 16-bit ADAT. How much is 10 dB? From a laboratory standpoint, 20 dB stands for 100 times the power—so the dynamic range increase is analogous to the difference between a 10-watt amplifier and a 1000-watt amplifier. Because of the logarithmic nature of human hearing, to most people, each -10 dB of difference sounds “half as loud”, so the noise floor of the EC-2 will be perceived as 1/4th that of a standard CD.

The resulting 112 dB dynamic range is not only more than that found on a standard Compact Disc, it is much wider than the acoustic dynamic range of even the best recording studios. When you record analog audio directly into an ADAT HD24 upgraded with an EC-2, the recorder is literally no longer an issue in the overall sound quality. Even dedicated (and expensive!) outboard converters connected to the ADAT Optical ports of the HD24 have a tough time beating the specs of the EC-2. With proper recording techniques, any noise or hiss you hear is coming from the self-noise of the microphones or preamps, not from the HD24.

When to use 88.2/96 kHz

Why 44.1/48 kHz?

Many engineers believe that the sampling rates that have been used up to now are less than ideal. The industry-standard sample rates were chosen at a time when digital storage was much more expensive than it is today. The “consumer” rate of 44.1 kHz was the lowest possible sampling rate that could still record and play back the highest frequencies in the commonly-accepted human hearing range of 20 Hz to 20,000 Hz. At a 44.1 kHz sampling rate, a 650 MB Compact Disc would be able to play back 72 minutes without interruption—the length of Beethoven's Ninth Symphony.

In an era before digital mixing consoles and computer workstations, the 48 kHz sampling rate was designated the “professional” rate for two reasons:

1. the slightly higher sampling rate allowed more room for the *antialiasing filter* to do its work, and
2. professional recorders needed to be able to “pitch down” 12% and still play back the full 20 kHz frequency range.

The case for a higher sampling rate

While the traditional sampling rates give excellent performance (especially with today's converter technology), there is criticism that these rates are too low to obtain truly audiophile quality. Most of this criticism centers on the filters that are necessary to make digital audio work.

Antialiasing filters

The Nyquist theorem, upon which digital audio recording is based, states that you can reliably record and play back any signal by sampling it at least two times the rate of the highest frequency you want to record. However, if there are any analog frequencies in the incoming signal that are higher than half the sampling rate, nasty-sounding reflections appear in the signal, known as *aliases*. For example, if a 47 kHz tone is sampled at 48 kHz, you'll hear a 1 kHz tone, right in the midband of the audio—hardly what you'd want to hear by getting “extended frequency response”.

So, early analog-to-digital converters had a steep “brick wall” analog filter on the input. To avoid

aliasing, the steeper the filter, the better. Some converters boasted 10th-order (-60 dB per octave) filters. For comparison, most loudspeaker crossovers have 3rd or 4th-order filters (-18 or -24 dB per octave).

The problem is similar on the output side—the 44.1 or 48 kHz sampling frequency itself has to be filtered out of the analog output from the D/A converter, or it will send ultrasonic signals into amplifiers and tweeters, making toast of them even if the speakers don't have response that high. This called for a steep *reconstruction* or *output* filter, between the D/A and the analog output.

Such steep filters keep ultra-high frequencies from turning into aliasing noise, but they have their own negative side effects. Like any equalizer, filters have phase effects below the frequencies they directly affect. So, although the first digital recorders and CD players had flat frequency response, they did not have flat phase response—in the top octave from 10 to 20 kHz, the sound would start going through a small time delay as it approached the cutoff point of the antialiasing filter. In the opinion of critical listeners, these filters gave digital audio a harsh and unnatural high end. Since this phase response was often the only significant measurable difference between the input and output signals, designers focused on eliminating it (although it was never proven to be audible).

Digital oversampling filters

Throughout the 1980s and 1990s, engineers made quantum improvements in the design of A/D and D/A converters. Key among these was the development of digital oversampling filters. To vastly oversimplify, an oversampling filter sets its sampling frequency at a high multiple (originally 8 times, now usually 64 or 128 times) of the final sampling frequency. Then, most of the filtering takes place digitally, by throwing out the “extra” samples. A digital recorder or player with oversampling filters on its converters still records and plays back at the standard 44.1 or 48 kHz rate, but the analog antialiasing and reconstruction filters don't need to be “brick wall”: a 12 dB per octave filter is just fine, since the sampling is taking place much higher than the audible range. Therefore, today's CD players and digital recorders have almost perfectly flat phase response within the audible frequency range. (For more detail on this, we recommend *The Art of Digital Audio*, by John Watkinson.)

However, a digital filter with perfectly flat phase response still filters out frequencies above 20 or 22 kHz. Good analog tape recorders are capable of recording beyond 30 kHz. And there are those who believe that higher frequencies, while perhaps not audible in themselves, may have an effect on the quality of the audio taken as a whole.

Can you hear it?

You now have in your hands a tool that can let you hear the ultimate in recording for yourself. By making comparison recordings at 48 kHz and 96 kHz, you can judge what type of program material should be recorded at the higher rate, and what effect that has. But for an accurate comparison, make sure that everything else in the record/playback signal path has flat response (see “Extending the frequency range...” on the next page).

Extending the frequency range of other studio equipment

Even though an ADAT HD24 equipped with the EC-2 upgrade gives you the capability of recording audio beyond 40 kHz, many other elements of your studio may need to be upgraded to truly take advantage of this capability. Most studio equipment was designed to meet a 20-20 kHz spec, not the 44 kHz range that the EC-2 can record. Many devices treat anything above 20 kHz as nothing more than noise and may have low-pass filters that cut it off. To make truly wide-range recordings, make sure that every component of the signal chain is capable of ultra-wide response:

- Look for measurement microphones, usually small-diaphragm condensers, with response beyond 30 kHz. Most microphones are limited to 20 kHz response.
- An ideal mic preamp for 96 kHz recording should be flat to at least 70 kHz. Make sure the microphone preamp does not have built-in low-pass filters in an attempt to keep RF (radio frequency) noise out of the circuitry. They still need some filtering, but a well-designed preamp filters out RF without filtering audio.
- Many mixing consoles also have internal filtering to cut down on crosstalk, etc. These are often critical to low noise operation, so in some cases your best bet is to bypass the console during tracking and save it for only the final mix. Plug high-grade microphone preamps directly into the balanced inputs of the HD24/EC-2. Or, have your console custom-modified to raise its low-pass point by someone who understands the tradeoffs between noise, stability, and frequency response.
- For listening to a high-sample-rate recording, electrostatic headphones (e.g., Stax) or monitors with electrostatic or ribbon tweeters are your best bet. Most studio monitors don't respond well to frequencies above 25 kHz, if they respond at all. A soft-dome tweeter trying to reproduce 30-40 kHz often goes into irregular modes that may, oddly, sound "good" to a listener, but they're not really playing back what was recorded.

If you've done all the above, and confirmed your studio's capability of reproducing the full range of frequencies the HD24/EC-2 can record, you now have a truly state-of-the-art studio that's capable of mastering audiophile-quality DVDs and SACDs. Though the extra octave of high end may not be audible to the majority of listeners (or even to you, especially if you've been listening to loud music for too many years), you can be assured that what you're recording will stand the test of time, for all listeners. Audio technology won't get significantly better than this.

Good luck and thank you for using the ADAT HD24 with the EC-2 96 kHz Upgrade!

Using the HD24/EC-2 with computer workstations and digital mixers

Because the EC-2 upgrade provides 24 high quality inputs and outputs, it can be used as an external converter to extend the number of analog inputs and outputs of any computer workstations and digital mixers that feature an ADAT Optical interface. When using it as an A/D converter, press the **ALL INPUT** button with **INPUT SELECT** set to **ANALOG**; when using it as a D/A converter, set **INPUT SELECT** to **DIGITAL**.

Remember that for an input or output to be active, the current Song must be initialized for the proper number of tracks, even if you're not recording or playing back the HD24 itself.

For more information see pages 39-40 in chapter 3 of the HD24 manual, *Basic Recording and Playback*.

High sample rate operation

If you want to use the HD24/EC-2 with a workstation or digital mixer at the 88.2/96kHz sampling rates, the question to ask the manufacturer of the other unit is: "does this support the 'sample-split' implementation for 96kHz audio transmission, with 4 channels of 96K/24-bit audio per ADAT Optical cable?" The details of this format are outlined by the Alesis Optical Interface Specification Addendum, February 2001. If it doesn't, instead of treating each lightpipe as a high-speed 4-channel interface, the workstation will use it as the traditional standard-speed ADAT Optical 8-channel interface. If that's the case, you'll get apparently "duplicate" signals on the device receiving signal from the HD24 in 96 kHz mode: Track 1 will appear on channels 1 and 2 of the digital mixer or workstation, etc.

In some cases, you need to manually set the other device to send and receive a 96k signal on the ADAT lightpipe. In other cases, you may need to upgrade the software or hardware of the unit so it can interface digitally. Contact the manufacturer of the workstation or mixer for more information.

Latency

Every digital conversion requires a certain amount of time, although the time delay involved is usually less than the time it takes sound to travel one foot through the air. However, if you have a digital workstation that allows compensation for input and output delays, see the Specifications section on page 13 of this manual for latency figures. In most cases, this is only critical when you're using different interfaces simultaneously (for example, the analog inputs of a computer interface plus its ADAT Optical inputs receiving the output of the HD24). In extremely critical applications, you should test latency matching by using a 20kHz burst tone sent to all inputs simultaneously, viewing the start point of the waveform bursts on the screen of a digital audio workstation, then adjusting the start times of all tracks to compensate.

Using the HD24/EC-2 with the Alesis AI-4 AES/EBU Interface

The Alesis AI-4 AES/EBU Digital Audio Interface is a single-rack space unit available from your Alesis dealer that lets you connect ADAT Optical input and output signals to industry-standard AES/EBU digital signals, eight channels at a time. The AI-4 is designed to handle standard operation, as well as high sample rates (88.2/96kHz).

With the AI-4 you can:

- Export tracks from the HD24 to mastering units (such as the Alesis MasterLink), DAT recorders, and workstations
- Import tracks to the HD24 from any recorder or source with an AES/EBU interface.

Using the AI-4 at 88.2/96 kHz

The AI-4 is ALWAYS capable of eight-channel conversion, simultaneously—each of the AI-4's four AES/EBU inputs and outputs carries a stereo signal, regardless of sample rate.

The only difference at the high sample rates is that a second pair of ADAT Optical cables must be used to connect the **ADAT OPTICAL 9-16** jacks on the back of the HD24 to the **ADAT OPTICAL (5-8)** jacks on the back of the AI-4. This is because the ADAT Optical interface transmits four channels of high-speed data, in the space used for eight channels of standard-speed data.

Remember that if you're transferring more than eight tracks at a time to the HD24, and must do multiple passes, there should be some synchronization via ADAT Sync at the same time. If the workstation doesn't have ADAT Sync, you should use multiple AI-4s to download all tracks at the same time.

Word clock

In a simple transfer between the HD24 and the AI-4, a separate word clock connection is not necessary, because word clock is contained within the ADAT Optical signal. However, in more complex multipath situations, the AI-4, HD24, and all other digital devices in the studio should be connected to a separate word clock generator and set to use this external word clock source as the timing reference.

Specifications

For the Alesis HD24 with EC-2 96 kHz Sample Rate Upgrade A/D and D/A Converter Boards:

AUDIO INPUT

Input Connectors:	24 balanced 1/4" TRS jacks
Nominal Input Level:	+4 dBu ($1.23 V_{RMS}$) = -15 dBFS
Maximum Input Level:	+19 dBu ($6.9 V_{RMS}$) = -0 dBFS
Input impedance:	10 k Ω
A/D converter:	AKM 5393
Analog filter:	2 nd -order Butterworth filter w. 96 kHz corner frequency
Latency (analog in to digital out):	Approximately 45 samples (<1 ms. @ 48 kHz)

AUDIO OUTPUT

Output Connectors:	24 balanced 1/4" TRS jacks
Nominal Output Level:	+4 dBu ($1.23 V_{RMS}$) = -15 dBFS
Maximum Output Level:	-2 dBu when connected to unbalanced circuit +19 dBu ($6.9 V_{RMS}$) = -0 dBFS +13 dBu when connected to unbalanced circuit
Output impedance:	220 Ω
D/A converter:	AKM 4393
Analog filter:	2 nd -order Butterworth filter w. 96 kHz corner frequency
Latency (digital in to analog out):	Approximately 32 samples (<0.7 ms. @ 48 kHz)

AUDIO PERFORMANCE

Signal to Noise Ratio:	112 dB A-Weighted, Analog In to Analog Out
THD+N:	$\leq 0.002\%$
Frequency Response:	22-44 kHz ± 0.50 dB
Throughput delay (analog in to analog out):	Approximately 77 samples (0.8 milliseconds @ 96 kHz, 1.6 milliseconds @ 48 kHz)
Sampling rates:	44.1, 48, 88.2, and 96 kHz (each variable $\pm 12\%$)
Channel to Channel Gain Match	± 0.50 dB

All measurements done over a 22 Hz - 22 kHz range with 1 kHz sine wave at +18dBu (-1dBFS) input unless otherwise specified. Impedances are measured at 1 kHz.

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